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SEWAGE PURIFICATION

Denton, Eardley Fraser Bailey-

SEWAGE PURIFICATION

BROUGHT UP TO DATE, 1896

BY

E. BAILEY-DENTON

M. INST. C.E., B.A. EXON. COLL. OXON.

London:
E. & F. N. SPON, 125 STRAND

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1896

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SEWAGE PURIFICATION.

LAND TREATMENT BROUGHT UP TO DATE.

1896.

It is not the wish of the writer in the following pages either to appear as the advocate solely of land treatment, or as being desirous of throwing indiscriminate discredit upon chemical processes which, as all sanitary engineers must acknowledge, are oftentimes advantageous, and sometimes unavoidable; but it is his aim to prove that except in those few cases where suitable soil cannot be obtained at anything like a reasonable price, or within a reasonable distance, land can still be relied on to permanently cleanse sewage at a moderate outlay; and at the same time to secure the effluent finding its way into any neighbouring stream being well within the limits of the well-known standards suggested by the Rivers Pollution Commissioners in 1876, and recognised by the Government of the day, as applicable to inland towns.

It cannot, however, be denied that, owing to neglect in the efficient maintenance of sewage farms by the local authorities responsible for their success after the engineer who designed them has completed his duties, the extension of land treatment has received a check during the last few years; but the writer is convinced that this temporary withdrawal from favour will cease when the public have realised the necessity of more careful management, and have had more experience of the great annual cost incurred in the proper conduct of chemical works. Recent experience has proved that the general objections taken to

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sewage farming may be obviated by simply passing the liquid in its crude state through broken ballast, gravel, coke, or some other suitable material before its application to land; and by the adoption of this simple form of rough filtration, not only are all these objections satisfactorily overcome, but the area of land utilised may be considerably reduced, and at the same time the best results obtained.

The objections referred to are:—

(1) The disagreeable appearance of the surface of the land owing to the deposition upon it of the larger solid matters contained in suspension in the liquid sewage.

(2) The gradual clogging of the interstitial spaces of the soil through which the liquid sewage has to travel.

(3) The slower rate of filtration in consequence of this clogging, and the giving off of effluvium, owing to the liquid constantly remaining stagnant on the surface, instead of passing directly through the soil.

From the frequent announcements in the press and elsewhere of the successful doings of the several chemical companies which have by fits and starts occupied the public attention during the last ten or twelve years, an idea seems to have sprung up that land as the purifier of sewage is no longer a success, and that recourse to chemicals in some shape or other is becoming unavoidable; whereas the real reason that so little has been heard lately of this natural treatment is, not that it has been a failure, but that there was nothing fresh or of a particularly striking character to say about it.

That the belief in the success of land treatment, wherever practicable, is well founded by those who have made such treatment their special study, is supported by all the statements made at the last discussion held at the Institution of Civil Engineers, in April 1893, upon a paper read by Mr. Roechling on 'The Sewage Farms of Berlin.'

Mr. Baldwin Latham, who has had exceptional experience in the sewage question, then said:—

"He would not say that sewage farming was the only mode of dealing with sewage, but there could be no doubt that it was the best mode where land could be got at anything like a

reasonable rate and within a reasonable distance of a town. Under such circumstances it was the most effectual, the simplest, and often the cheapest method that could be adopted."

Sir Robert Rawlinson, K.C.B., late President of the Institution, said:—

"The result of his experience and of all the knowledge he had gained, having served on two Royal Commissions appointed for the special purpose of investigating the sewage question, was that crude sewage in its simplest form, without tampering with it by chemicals, was the best form for the land, and would produce the best results if applied judiciously in proper dilution, in proper quantities and at proper times."

Colonel Jones, who for many years was the tenant of the Wrexham Sewage Farm, and has recently been appointed, by the War Office, manager of the Aldershot Camp Sewage Farm, in order to rectify the effects of the neglect of past years, after showing that careful attention to detail is always necessary for successful sewage treatment, gives his reason for sewage farms not growing in favour in England in the following terms:—

"Unfortunately, there had been in England a number of sewage marshes, miscalled sewage farms, that had been very badly managed, and which had given rise to the idea of the land becoming sewage sick. . . . Careful attention to cleanliness in every detail was essential to every kind of sewage disposal. It was nearly everywhere afforded in precipitation works, but as a rule it was denied to sewage farms. The reason was that patentees and persons interested looked after the one, while in the other case the engineer who had laid out the farm went his way, and it was left to a committee of town tradespeople to look after."

Sir Douglas Galton, K.C.B., stated that all evidence proved that:—

"Where sewage farms were carefully managed they were not either unhealthy or offensive; but that the success of every method of sewage disposal, including irrigation, depended on local circumstances, amongst which proper management was of the first importance."

On the other hand, what did those chemical authorities who were present at the meeting say, from none of whom a preference for purification by means of land would have been expected?

Mr. Dibdin, chemist to the London County Council, stated that:—

"The general conclusions of the author were entirely in accordance with the views which he had himself submitted;" concluding his remarks with the very true observation, which ought to be more generally acknowledged, that there was no general way whatever for dealing with sewage.

Dr. Dupré went further, and said that:—

"He knew no one familiar with the subject who denied that the most effective treatment of sewage was by passing it through land, provided the land was suitable. He maintained that the effluent from a chemical treatment was not to be compared with the effluent from a sewage farm."

This fair treatment of the subject is very different to that so frequently indulged in by those who advocate throughout the country one or other of the numerous chemical processes which for a time find favour with the public, and who are generally utterly regardless as to whether the special form of treatment which they recommend is, or is not, suitable to the case in question, and who never seem to realise that what should be adopted, or is even necessary in one case, may be perfectly unsuitable for another.

As an example of how some of these specialists discuss the sewage question, the following expression of opinion, which appeared in the *Somerset County Mail* of May 10th, 1894, is appended:—

"Mr. Lailey told the Parochial Committee of Crewkerne that there was not a place in England at the present time where sewage irrigation answered alone. Where irrigation works had been put up, chemical treatment had to be combined; for after a time the land became sick, and could not receive the sewage."

One-sided statements like this must do incalculable harm if not contradicted, especially in the minds of those who have never studied the sewage question in any shape, and who are therefore easily influenced by them.

No one who has followed the advancement of sanitation during the last ten or twelve years with an open mind, can deny that chemical treatment is often necessary, owing to local circumstances; but it does not follow from this that its adoption should be by any means universal; on the contrary, it is exceptional; and therefore it is indeed opposed to the general welfare that professional men should thus uniformly advocate their special pet theories, wherever they go, regardless of those local details which should always govern their opinions.

The statement as expressed at the Institution of Civil Engineers in 1893, that the mismanagement of sewage farms had given rise to the idea that land frequently becomes sewage-sick, or is altogether a failure, is practically true; for it cannot be denied that in many instances, owing to the great desire of local authorities to be economical, the unavoidable expenses, inseparable from successful management, have been cut down to the very last degree, with the result that the careful and uniform application of the sewage to the whole of the land laid out for it has been abandoned, and that the purification of the sewage has been made subordinate to a "satisfactory balance sheet." The inevitable consequence has been that either the liquid is persistently applied to a small area instead of a large one; or that it is directly passed off the surface after practically no treatment whatever.

When making this assertion the writer acknowledges that sewage farms are not alone mismanaged, for there is no doubt that chemical works are, as frequently as sewage farms, the victims of a false idea of economical management; and that directly the newness of a sewage scheme has worn off, the expenses of maintenance are gradually reduced by curtailment in the use of that proper quantity of chemicals which is necessary to obtain a good result; except perhaps on stated occasions, when the public are invited, or ask to be allowed, to inspect the works, and when therefore a bad effluent would obviously be most undesirable.

This regrettable state of things will continue, both with regard to land and chemical treatment, so long as the Local Government Board do not appoint inspectors to periodically

visit the sewage works throughout the country, and to see that their management is efficiently maintained.

It was, it is to be presumed, as a result of this popular prejudice against sewage farms, that in the Session of 1893 the House of Commons, in sanctioning provisional orders for the establishment of sewage farms, insisted that before sewage shall be permitted to pass on to the lands to be acquired, "the fæcal matter in suspension shall be removed by passing the sewage through a tank or tanks and treating the same by subsidence or filtration through coke or other suitable material."

Such certainly were the words of the order with regard to the county borough of Northampton in 1893, which the writer, as the consulting engineer entrusted with the extension of the existing sewage farm, willingly complied with. As a result, a preliminary scheme of rough filtration (full particulars of which will be found on p. 10) was designed, and having been in operation most successfully for more than a year, he proposes to recommend its adoption in all other works upon which he may be consulted in the future, whenever either the land is not of the most porous description, or in cases where the quantity of sewage discharged is greater than under ordinary circumstances the area of land at command can purify.

By this means, there is no doubt whatever that in such instances chemical treatment, with the heavy annual cost inseparable from its efficient management, can be avoided, as well as the initial outlay incurred by the construction of large precipitation tanks, which must prove altogether useless should the use of chemicals be from any reason ever put on one side.

The paper by Mr. Dibdin, chemist to the London County Council, on the 'Filtration of Sewage,' delivered before the Society of Chemical Industry on the 4th of November of last year, in every way bears out the discussion of 1893 at the Institution of Civil Engineers. This gentleman, after repeating the fact that, if suitable soil is available, land is the best means of purifying sewage, describes in detail the experiments made by the State Board of Health of Massachusetts, U.S.A. He relates how the several experiments were conducted, the various filtering media being, *inter alia*, clean sand, very brown soil from

manured garden, coarse and fine sand, and fine gravel with and without sandy loam, as well as clay. Each filter had an area of $\frac{1}{200}$ of an acre.

The experiments with gravel stones gave the best illustration of the essential character of *intermittent* filtration. Here, without straining the sewage sufficiently to remove even the coarse suspended particles, the slow movement of the liquid in thin films over the surface of the stones with air in contact, caused to be removed for some months 97 per cent. of the organic nitrogenous matter, a large part of which was in solution, as well as 99 per cent. of the bacteria, which were of course in suspension, and thus enabled these organic matters to be oxidised, so that there remained in the effluent but 3 per cent. of the decomposable organic matter of the sewage, the remainder being converted into harmless mineral matter.

Mr. Dibdin then records the experiments recently made by the London County Council at Crossness with filters containing burnt ballast, pea ballast, coke breeze and sand. The results of his experiments proved that for foul waters sand was too fine and burnt ballast was too coarse, whilst coke breeze seemed to unite the necessary qualifications, and, therefore, as it was a cheap material, it was selected for further trials on a large scale.

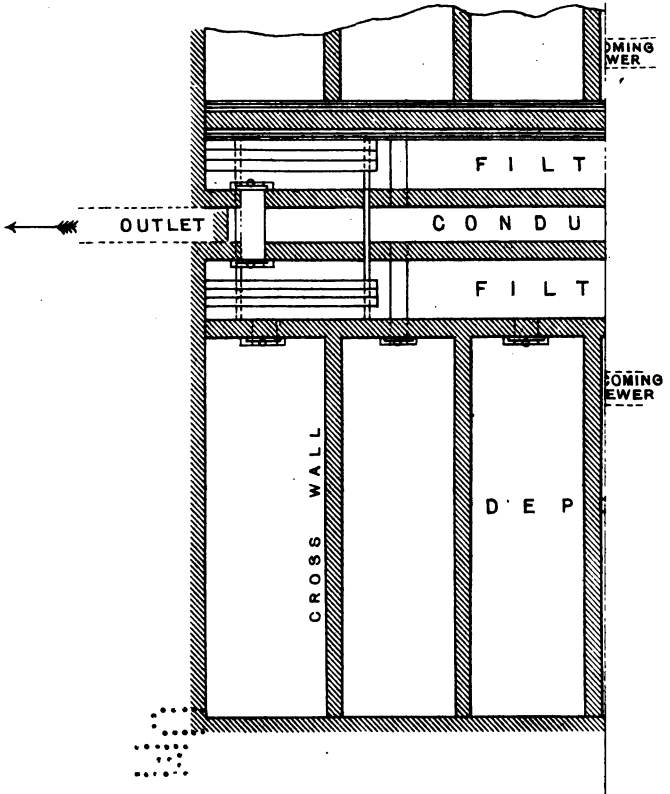
In the second series of experiments a filter was constructed covering one acre of land, the ground was levelled and embanked where necessary, and perforated drains laid, meeting in a common trunk for discharge. The filtering material consisted of 3 feet of coke breeze covered with 3 inches of gravel. Mr. Dibdin gives an interesting explanation of how these experiments were carried out, and summarises his approval of coke breeze by stating that if a reduction of 75 per cent. in the oxidisable organic matters in solution be considered as sufficient, the quantity of sewage that can be treated per day on one acre of coke breeze is 1,000,000 gallons; which gives the required area for the treatment of the whole of the Metropolitan sewage, already partially treated with lime—taken at 180,000,000 gallons—at 180 acres only. This rate is probably the highest that can be worked under all conditions of seasons.

Mr. Dibdin, however, in his paper, does not enlighten his readers as to the cost of these large artificial filters, which must prove an almost insurmountable drawback to their general adoption; whilst it must also be noticed that he does not guarantee a reduction of more than 75 per cent. of organic matter, as opposed to 98 per cent. secured, though on a small and experimental scale, in America, by intermittent filtration through gravel stones. It is also surprising that Mr. Dibdin makes no reference to the comparative value of the various chemical treatments now in use.

In order to bring his experience in land treatment up to date, the writer proposes to give eight examples (recent and otherwise) of sewage disposal works now in operation in towns where the population varies from seventy thousand to one thousand, instancing, in addition, a County Lunatic Asylum as well as a large private dwelling. In this manner he considers that he can prove his previous statement that, in the generality of instances the local authorities of all towns situated on soil not absolutely unsuitable, can with every chance of permanent success adopt land treatment without chemicals.

The towns selected are taken haphazard throughout Great Britain, with a view of showing that the area of country where the adoption of chemicals may be found to be necessary is, comparatively speaking, small. The examples are :—

Place.	County.	Population.
1. Northampton	Northants	70,000
2. Dewsbury	Yorks	30,000
3. Forfar	Forfar	15,000
4. Abingdon	Oxon	7,000
5. Great Malvern	Worcester	7,000
6. Wormley	Herts	900
7. County Asylum	Berks	800
8. School at East Grinstead . .	Sussex	80


OUTLET
CROSS WALL

NORTHAMPTON.

THE sewage of the town of Northampton, with a population of about 70,000, which is rapidly increasing owing to the development of the shoe and other trades, has been for the last twenty-five years treated upon land by means of broad irrigation over about 270 acres out of a farm of 327 acres, situated in the valley of the Nene, in the parish of Ecton, about four miles from the town. In 1891, however, owing to the increase of population and the difficulties in successful management consequent on the admission into the sewers of all the storm waters falling on the impervious surfaces of the borough, and thereby inundating the farm in times of heavy rainfall, the writer's firm were consulted, with the result that the Corporation purchased 205 acres additional land immediately adjoining that already sewaged, and this supplemental area is now being laid out for wide irrigation in combination with intermittent filtration.

The soil of both the original farm (to which the sewage is conveyed by gravitation), as well as the recent addition, is of a porous description, and when carefully laid out and properly underdrained, is very suitable for the absorption and purification of sewage. It may therefore be fairly assumed that as the land is now being turned to the best advantage, and as the corporation of the town have signified their intention of excluding the surface waters from any new sewers, and from the old sewers as suitable opportunities arise, the sewage difficulty has been here solved for many years to come.

The enlarged farm would, if the population were to double itself, receive the sewage of only 276 people to the acre, and

with such a porous soil as it possesses there should be no possibility of dissatisfaction unless the farm is mismanaged.

It cannot be denied that in the past the large quantities of diluted sewage discharged during periods of heavy rainfall on to the original farm, limited in area and insufficiently underdrained, have at times produced unsatisfactory results; for either the liquid remained for days at a time stagnant on the surface to give off evil odours, especially at or about sunset, or it immediately passed off unpurified into the river Nene, to the great annoyance of riparian owners and the destruction of fish. Consequently, when the Northampton Provisional Order was under consideration before the House of Commons in the Session of 1893, the Committee, before sanctioning the order, inserted the clause which is quoted on p. 6.

Owing to these requirements of the Committee, a scheme for skimming off the coarser solids floating on the surface, and for roughly filtering all the liquid before admitting it to the outfall sewer to flow to the farm, was devised by the writer, and carried out under the able supervision of the Borough Engineer, Mr. Gibbins, more than eighteen months ago, at the depositing tanks, which are situated near the town, in the Houghton Road. This design, illustrated on drawing No. 1, was considered to be the simplest and cheapest method of meeting the requirements of the Committee of the House of Commons; for by its adoption all the coarser matters in suspension are eliminated from the crude sewage, which, in consequence, upon its distribution over the farm, percolates more quickly through the soil than formerly, without leaving behind a disagreeable appearance on the surface.

The drawing clearly illustrates how this required filtration has been effected. It will be seen how the surface of the sewage, as it comes down from the town, is skimmed at the several cross walls of the tanks, and how afterwards the liquid passes through penstock openings into the bottom of the filter chambers, rising up through the filtering material to pass over the weir into the outfall conduit, and so on to the farm. The tanks being in duplicate, are used one at a time for a maximum period of a week each. After use the contents are allowed to

remain quiescent for a few days until all but the bottom water has become fairly clear, when the supernatant or top water, after passage through a basket or receptacle containing coke or ballast, is discharged, by means of pipes, directly into the effluent conduit. The liquid sludge left behind is raised by pumps on to adjacent sludge beds, under which there are shallow drains at close intervals, the trenches being filled up with ashes above the pipes. The solid is here mixed with the town ashes, which are subsequently purchased by neighbouring farmers, the liquid, after filtering through into the underdrains, being conveyed back again into the tanks. When the tanks are alternately emptied, the filtering material in the filter chambers, consisting of broken bricks or ballast, is automatically cleansed by the head of water lying over it, which washes all the arrested filthy matter straight into the pump-well, to be raised on to the sludge beds. By this means the thorough aeration of the filtering material is secured between each application of the sewage.

This process continues to act satisfactorily, and in support of this statement is appended a copy of a letter received from the farm manager, who thus wrote on 19th July, 1895:—

"DEAR SIR,—In reply to your letter of the 24th ultimo respecting the alteration to the tanks at the Northampton sewage works, and the consequent results on the farm since the same have been in operation, I beg to state that the rough sewage taken out of the tanks makes the liquid present a much more agreeable appearance when arriving at the farm, and I find that the sewage percolates much more quickly through the soil since the alterations have been carried out.

Yours faithfully,

(Signed) T. E. GOOSEY."

DEWSBURY.

THESE sewage disposal works, which were executed by the writer's firm some fifteen years ago, are of considerable interest, because the town, which has a population of 30,000, is, as is well known, one of the principal manufacturing centres in the valley of the Calder. At the present time, as when the works were opened, the quantity of liquid trade refuse of no manurial value discharged into the sewers is very considerable, whilst a good deal of surface water still finds its way down to the farm, known as "Michell's Lathes," and to the surface of which the sewage is raised at a pumping station situated on the farm.

The total acreage is 160 acres, of which only 73 have been prepared for sewage purification. Of this area, 60 acres are laid out in large flat beds of about two acres in extent each, for intermittent filtration, whilst the remainder is roughly prepared for wide irrigation.

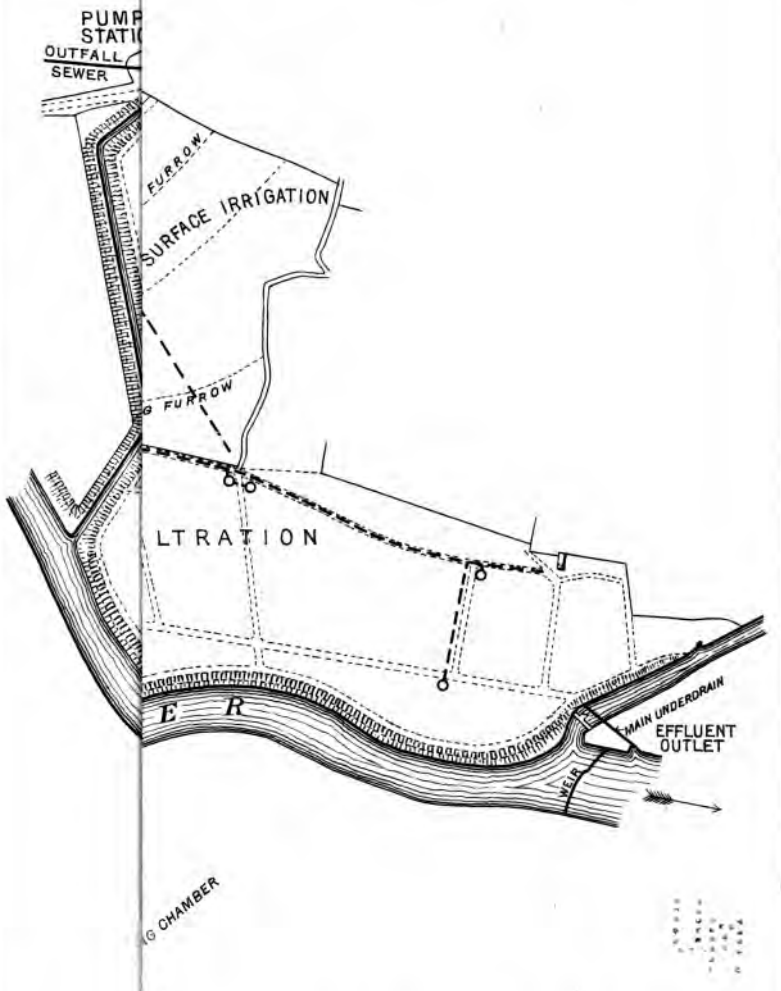
Except at the screens which are placed in the pump well, there is no abstraction whatever of the solid matters in suspension, and no artificial filtration of any kind. The soil for the most part is of a sandy character, very porous, and most suitable for the purpose.

The work of preparation was more than ordinarily expensive, owing to the necessity of forming the surface into comparatively few horizontal areas. This involved a great quantity of earth work, and raised the initial outlay to about 110*l.* per acre. Considerable expense was also incurred in substituting a new outfall channel for a brook named the "Chichenly Beck," which previously ran through the farm; and in the construction of roads, besides the erection of a boundary wall

Nº 2.

Y, YORKSHIRE.

OR SEWAGE CLEANSING.



BAILEY, DENTON, SON & NORTH,
PALACE CHAMBERS, WESTMINSTER.

Thos Kell & Son. Lith

The principal feature of this farm is its capacity of absorbing and cleansing far more sewage than is at present discharged over it. With the existing population, if all the 63 acres were utilised, the rate of sewage per head per acre would amount to about 550; but it is very seldom, if ever, that the sewage is applied to *all* the filtration areas during the same season, for, generally speaking, cereals are grown on more than half, which, in consequence, is given a complete rest for a considerable period. There is therefore no doubt whatever, that if the numerous chemical ingredients used in the trades of Dewsbury were altogether excluded, the flocculent solid refuse properly screened from the liquid, and the surface waters diverted from the sewers as far as possible, the sewage of at least 1000 people to the acre could be permanently purified on the same area as now, without the successful growth of the ordinary crops generally associated with sewage farming being in any way interfered with.

The works were completed in 1879, and to show that the efficient character of the farm has been continuously maintained since that year, the writer appends the two following letters.

The farm manager on the 25th May, 1884, thus wrote:—

"The sewage is doing better this season than before, and the crops are looking very fair, but we cannot expect very heavy crops, as the land is poor, some of it having been cropped four times without having manure of any kind. The sewage consists chiefly of dye-wash; nevertheless, the effluent is very good, and every one that sees it is surprised to see how clear it is. There are a great many mill hands come to have a bathe at the outlet, it being the only clear water for miles that they can bathe in."

This fact is striking, because it was from this part of the Calder that the Rivers Pollution Commission took the *water* wherewith to write their "memorandum," thus showing the condition of the river.

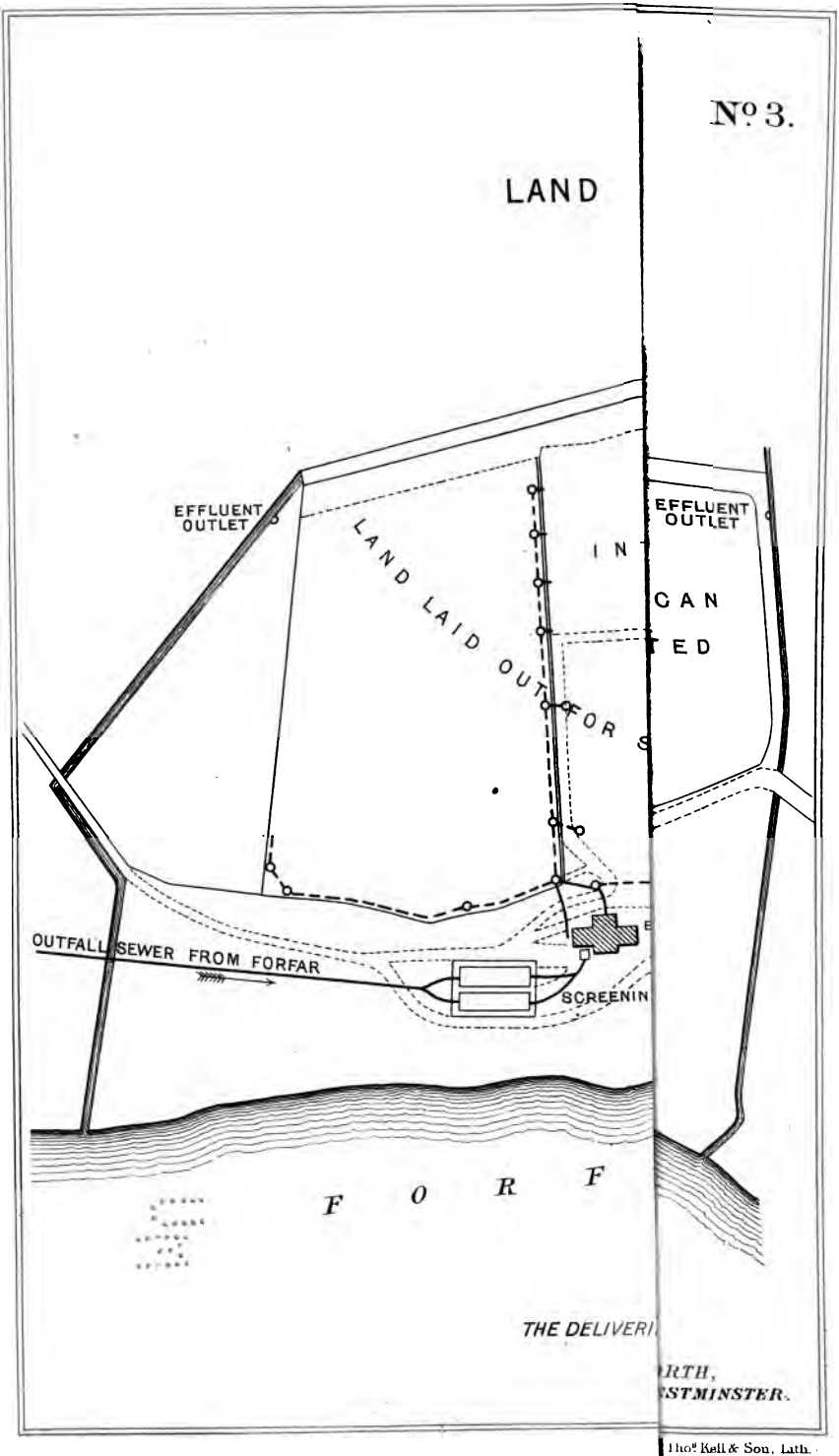
On July 1st, 1895, the borough engineer wrote, in reply to a letter of inquiry addressed to him, that—

"The crops are looking well; the land is taking the sewage as freely as when the farm was first laid out."

"The effluent is satisfactory, and the farm is taking all the sewage of the town."

The engineer adds, however, that during the preceding year (1894) the Corporation did not have a balance to their credit, probably owing to the heavy summer rainfall and to universal low prices.

Drawing No. 2 shows the position of the pumping station in relation to the land, the low and high level rising mains, the filtration areas, the irrigation land, and the point of discharge of the purified effluent into the river Calder below the adjoining weir.


No 3.
LAND
EFFLUENT OUTLET
LAND LAID OUT FOR
IN
CAN
ED
EFFLUENT OUTLET
OUTFALL SEWER FROM FORFAR
SCREENIN
F O R F
THE DELIVERI
RTH,
STMINSTER.
Thos Kell & Son, Lith.

FORFAR, SCOTLAND.

THIS burgh is the county town of Forfarshire, and has a population of about 15,000. The mode of disposing of its sewage is that of intermittent filtration combined with surface irrigation in the proportion of one acre of the former to three of the latter. It was the first operation of its kind in Scotland. Previous to the adoption of this system of disposal, the sewage flowed without any treatment into the Loch of Forfar, the property of the Earl of Strathmore, who, to protect his estate from injury by the pollution of the loch, took proceedings through the Court of Session and compelled the Sanitary Authority (the Commissioners of Police) to adopt a means of cleansing its sewage. The quantity of sewage in dry weather varies from about 400,000 gallons to 600,000 gallons daily.

In 1877, Mr. Willett, C.E., of Aberdeen, was employed to effect the sewerage of the town, whilst the writer's firm were called in to advise as to the disposal of the sewage, which resulted in the adoption of the treatment mentioned. The Commissioners purchased for the purpose, at a cost, with expenses, of 4000*l.*, "Orchard Bank Farm," containing about 40 acres of land adjacent to other property belonging to the burgh, which may ultimately, if required, be utilised for sewage purification.

The disposal works were executed in 1878 and 1879, at a cost of 1450*l.*, or 60*l.* an acre, and when accepted from the hands of the engineers, were described in the local paper in the following terms :—

"The quantity of land prepared at Forfar to receive and cleanse the present sewage is confined to about 24 acres only

out of the 40 acres, and the mode of treatment adopted is intermittent downward filtration, combined with surface irrigation. The area of land devoted to intermittent filtration is 7 acres, leaving 17 acres for surface irrigation. The soil is of a free and open character, sandy and gravelly in parts, though occasionally partaking of a somewhat loamy character. The land may be described as admirably suited for the filtration of sewage, but in order to avoid all chance of supersaturation, a main underdrain, with subordinate drains, has been laid, which will keep down the subsoil water, and secure aeration, and so allow of perfect percolation of the liquid distributed over the surface of the ground.

"The filtration areas are laid out in a series of terraces, each terrace being on a perfect level, to be intersected by main furrows traversing their whole length, with branch furrows cut at right angles to the main ones. The main furrows are deeper than the branch furrows, in order that they may receive the solid matter floating in the sewage, which will deposit itself in them, and allow the liquid to be distributed by the branch furrows evenly through the soil. The intermediate ground between furrow and furrow is planted with vegetables, the roots of which help themselves to what they require of the sewage, and will yield abundant crops.

"The terraces forming the filtration areas, and the delivery of the sewage to them, are so arranged that each terrace can receive its quantum of sewage separately from the rest, or two or three can be served at the same time according to the quantity of sewage to be disposed of. After they have received 'their fill,' the sewage will be turned on to other terraces, which in their turn will receive their quantum. By this means that intermittency of application and consequent aeration, upon which the oxidation of the putrescible ingredients of sewage depends, will be effected.

"The fields laid out for wide irrigation are prepared very differently from the filtration areas, inasmuch as the sewage is distributed over them on the 'catch-water' system, without any great alteration of surface configuration. The distributing carriers follow the natural contour of the land. When filled,

the sewage overflows their edge and runs down the natural slope of the land towards the next carrier, which is again filled to overflowing. The whole will be under the charge of the 'waterman,' who controls and distributes the sewage in suitable quantities by means of 'stops,' which he places in the carriers when required to check the flow."

The land was partially sown and planted in the year 1879. After more than twelve months' experience the convener of the Water and Sewage Committee, Mr. Whyte, on the 18th day of October, 1880, reported to the Police Commissioners that from the experience they had gained, it was evident that the sewage farm would not only pay itself, but perhaps the charge for the pumping station besides. In support of this he laid before them the following tabulated statement of the year's produce:—

SEWAGED LAND.

East Field—Rye Grass.

			£	s.	d.	£	s.	d.
Crop No. 1	21 tons 14½ cwts.	. . .	20	5	4			
„ „ 2	26 „ 5½ „	. . .	19	13	4½			
„ „ 3	34 „ 7½ „	. . .	26	12	8			
„ „ 4	34 „ 3 „	. . .	25	12	3			
„ „ 5	9 „ 5½ „	. . .	6	19	1½			
5 acres 6 poles, 125 tons 15½ cwts., or 19*l.* 13*s.* 4*d.* per acre						99	2	9

West Field—Rye Grass.

Crop No. 1	21 tons 12½ cwts.	. . .	19	7	0½			
„ „ 2	28 „ 14½ „	. . .	24	14	5			
„ „ 3	34 „ 19 „	. . .	29	0	9			
„ „ 4	25 „ 9½ „	. . .	19	2	1½			
5½ acres, 110 tons 15½ cwts., or 16*l.* 13*s.* 6*d.* per acre . .						92	4	4

Filtration Areas.

	Per Acre.	tons.	cwts.	lbs.						
Crop No. 1	Cabbages .	10	3	4	.	13	3	11		
„ „ 2	Carrots .	55	6	8	.	29	2	9		
„ „ 3	Turnips .	12	13	0	.	6	12	10		
„ „ 4	Mangolds	21	0	0	.	43	17	10		
„ „ 5	Swedes .	13	6	9	.	18	5	9		
									111	3	1
	Carried forward . . .								302	10	2

Outer Lands Sewaged, &c.

	£	s.	d.	£	s.	d.
Brought forward . . .				302	10	2
2¾ acres of turnips, 8*l.* per acre . . .	22	2	11			
Potatoes, 5 tons Myall's Kidneys, 4*l.* per ton	20	0	0			
Potatoes, 5 tons Regents and Champions, 3*l.*	15	0	0			
Savoys—say 1½, 20*l.*	30	0	0			
Barley, 2 qrs., 25*s.*	2	10	0			
				89	12	11
Rent—Mr. Mount, Farm House, &c. .	30	0	0			
Rent—Mr. Graham, Land not sewaged .	20	2	7			
				50	2	7
Total receipts from Farm . .				£442	5	8

Mr. Whyte, continuing, said, "they might reasonably look forward to even better results from the filtration areas. Coming to the debit side, he took the cost of Orchard Bank and the expenses, 4000*l.* at 4 per cent.—and 160*l.* was the rent of the farm. The expenditure for laying out the farm amounted to 1450*l.*, to which some little additional expense had had to be added, and he put the total at 1500*l.*, or at 4 per cent., 60*l.* All the expense of working did not apply to the crop, but he had put down 150*l.*, which he believed would cover the expense. There was then a total of 370*l.* as the cost of the farm. There was thus a balance of 72*l.* 5*s.* 8*d.* in favour of the farm on the season."

At the same meeting the Commissioners came to the following resolution, which was signed by the Provost of the Burgh and forwarded to the Engineers:—

"*Forfar Sewage Disposal.*—After the experience we have now had of the sewaged land at Orchard Bank, we have pleasure in expressing our entire satisfaction with the manner in which you have designed and carried out the works for the disposal and cleansing of the sewage of this burgh. With respect to the actual cost of the works, we find that you have prepared seven

acres for intermittent filtration, and 17 acres of hilly land for surface irrigation, and have distributed the sewage over the whole by glazed stoneware and iron pipes connected with chambers of masonry for the sum of 1450*l.* This amount includes the wages of Mr. Jonas Harris, the Clerk of Works, for more than a year, during which time he has attended not only to the cultivation of the farm, in addition to the work of preparation, but to sundry matters connected with the sewerage of the burgh. It also includes the construction of roads, the alteration of fences, the purchase of weighing machine, and the payment for seeds for land, as well as other acts of husbandry. The filtration areas are capable of absorbing and cleansing the whole of the sewage of the burgh when it is not distributed over the land laid out for surface irrigation. Vegetable crops of considerable weight are grown on the former, while rye-grass occupies the latter, and a fair return is to be anticipated. The effluent is always most satisfactory.

"Passed at a meeting of the local authority of the Burgh of Forfar, held on the 18th day of October, 1880, and signed for and on behalf of the said local authority by me.

JOHN LAWSON, Jun.,
Provost."

Continued Success of the Sewage Farm.—To show that the success of the farm continues uninterruptedly, the author appends extracts from a letter from the farm manager, written under date August 3rd, 1895, which states:—

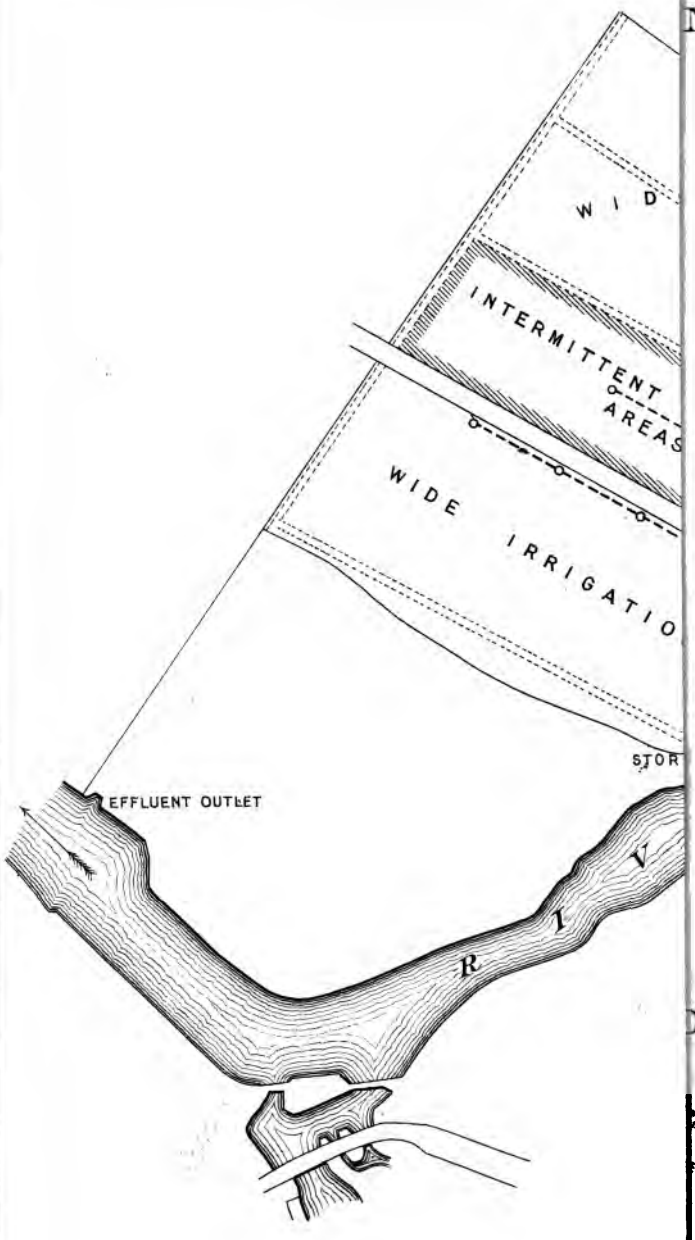
"In my opinion the farm has done and is doing very well. The filtration areas act as well as ever. . . . There is no nuisance of any kind, and the effluent is quite clear and free from smell."

He at the same time enclosed three balance sheets for the years ending May 15th, 1893–1894–1895. In the first year the profit in favour of the farm was 224*l.* 5*s.* 5*d.*, in the second 206*l.* 5*s.* 7*d.*, and in the third 159*l.* 10*s.* 6*d.*, a result which, although declining owing to consecutive bad seasons, is highly satisfactory. The last year's balance-sheet is thus made up:—

Receipts.	£	s.	d.
Proceeds of crops off sewage farm—			
Turnips and mangolds .	169	0	10
Vegetables	21	12	9
Grass and pasture . .	125	3	8
Oats	71	2	10
Year's rent of house .	10	0	0
Sand	3	10	5
	£400	10	6

Expenditure.	£	s.	d.
Wages	132	5	7
Horse labour . . .	48	5	5
Seeds	26	15	0
Lime and manure . .	0	16	0
Implements and repairs	11	18	0
Year's rent of field . .	15	0	0
	241	0	0
Profit .	159	10	6
	£400	10	6

Drawing No. 3 illustrates the entire scheme of sewage disposal, showing the relative position of filtration areas and irrigation land, as well as that of the pumping station and the adjacent loch of Forfar.



Nº 4.

ON

Helens
hurch

INSTER

Kell & Son, Lith.

ABINGDON, BERKSHIRE.

At Abingdon, where the soil is, as is so frequently the case in the Thames valley, very open and porous, the sewage is cleansed by surface irrigation in conjunction with intermittent filtration in the proportion of four acres of the former to one of the latter. The works have been completed fourteen years. The population of the town is between 6000 and 7000, and the quantity of sewage discharged daily approximates 220,000 gallons in dry weather, which is often increased to double that quantity in wet weather, the excess being due to the fact that the private sewers communicating with the public sewers of the town still receive the rain falling on the back roofs and impervious surfaces connected with the houses.

The number of acres constituting the farm is 48, of which 27½ were laid out for surface irrigation, whilst the quantity devoted to filtration is 6½ acres, making a total of 34 acres actually sewaged.

After a few years of management by the Corporation, the capability of getting rid of the sewage on the filtration areas only when not wanted on the irrigation land proved such an advantage, that the Council were enabled to let the land with the sewage at 4*l.* 10*s.* an acre, its agricultural value as ordinary farming land being less than half that rent. Instead of finding the sewage too much far the land, the tenant applied to the Council to allow him to discontinue the application of sewage to about 8 acres out of the 27½ acres devoted to surface irrigation, and these, after permission was given him, he laid down to permanent pasture. The Corporation have, however, since then reverted to the original arrangement, and have taken the

management of the farm again into their own hands. The land laid out for filtration is divided into five beds, averaging nearly 1¼ acres each, and such is the absorptive power of the soil, that the daily quantity of sewage is frequently applied to one area only for several weeks together without overfilling the furrows.

A short time after the completion of the works a deputation from Salisbury paid a visit to the farm and reported that "Half an acre will take a day's sewage, and 7 acres of rye-grass will take the sewage during the whole summer."

That this satisfactory state of things is continued is confirmed by a letter from the Borough Engineer, Mr. George Winship, A.M.I.C.E, who thus wrote, on August 12th, 1895:—"The land under treatment looks remarkably well, and the crops are flourishing. It takes the sewage as freely to-day as it did the first day it was applied. The effluent is good."

Experience at Abingdon, therefore, has incontrovertibly shown that with the most favourable soil the liquid of 3300 people may be permanently dealt with successfully on a single acre, as suggested by Dr. Frankland, the only condition essential to success being that intermittency of application shall be adhered to. The effluent from the sewage land at Abingdon, which is mixed with a good deal of subsoil water, was frequently analysed by the late Dr. Tidy and Professor Attfield, who declared it to be "equal in purity to some waters used for drinking."

The absence of smell from the surface of the land is unquestionable, for although a public road runs directly through the farm, no complaint whatever of nuisance is ever heard.

The cost of preparing the land for irrigation was a trifle over 70*l.* an acre, whilst that of preparing the filtration areas was 85*l.* an acre. These figures include the delivery conduits, carriers, chambers, roads, iron fencing, quick fencing, and other incidental expenses, as well as engineering charges.

The total outlay for preparing the 34 acres of land to receive the sewage, and for the building of a farmstead and bailiff's cottage, amounted to 3470*l.*, making, with the cost of the land (48 acres) a total outlay of 10,640*l.* When the farm (48 acres) was let on lease for 225*l.* a year, it yielded an income equal to

2⅛ per cent. on the cost of land and preparation. This went in the reduction of the district rate, whilst all expense in distribution was saved to the borough.

It should be observed that as the preparation of the land, including the erection of cottage and farm buildings, cost the borough 3470*l.*, the total acreage outlay only just exceeded 102*l.* an acre, which is not half the amount often laid out per acre elsewhere without any buildings whatever.

At Abingdon there is no separation of the sludge from the liquid before it is applied to the land for purification. Whatever passes through the screens and is raised by the pumps is distributed over the surface by contour grips where the sewage is used for irrigation, or by furrows at regular intervals where it is used for filtration, and no difficulty whatever is experienced in either case, nor is any smell perceptible at a distance of 20 yards. When the farm was let, so far from any difficulty or objection having been experienced from the retention of sludge in the sewage, the tenant sometimes complained that he had not sludge enough, and that the liquid was absorbed by the land too quickly.

At the close of the year just past (1895) the same state of things was to be observed, and two hours after the cessation of pumping no sewage liquid was to be seen on the farm, whilst the effluent appeared to the eye to be clearer than the river itself into which it is discharged.

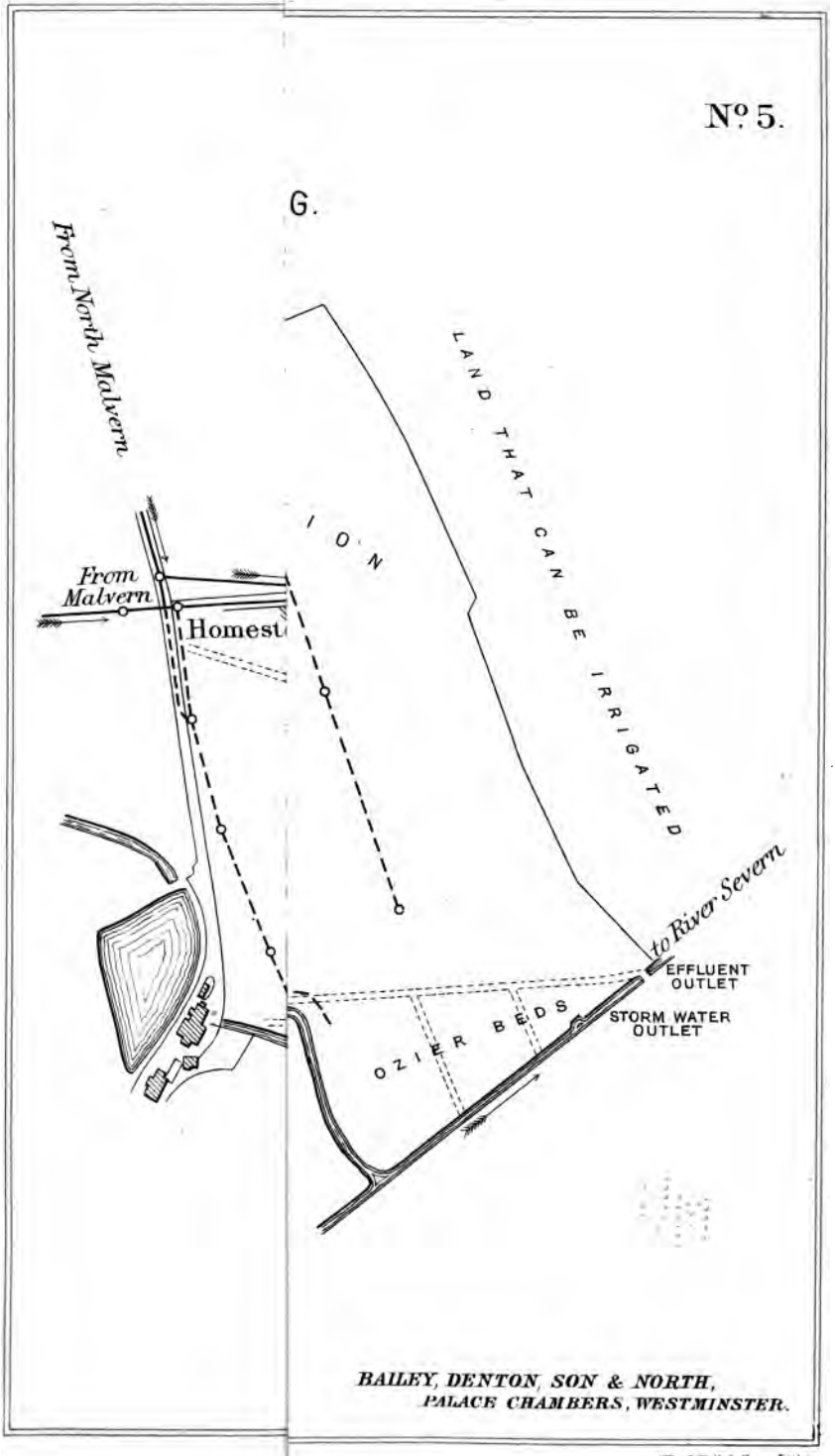
Drawing No. 4 illustrates the entire scheme, and shows how close the sewage farm is both to the town of Abingdon and to the River Thames.

GREAT MALVERN.

At Malvern, surface irrigation had been in practice for some years before the present treatment was adopted. Up to the year 1874 the sewage was discharged from that portion of the district known as Great Malvern on to land in the Pool Brook valley, which was partly devoted to permanent pasture, and partly to the growth of Italian rye-grass, without that careful preparation of the surface which is necessary if sewage is to be absorbed by the soil and those abuses avoided which are due to its overflow from the surface of the land into the outfall streams. In this instance the overflow was greatly increased by the heavy and sudden downfalls of rain which characterise the locality.

The land upon which the sewage was treated in the way mentioned was held by a tenant, who found it impossible to avoid the collection of fæcal matter in the slacks and hollows of the surface and the washing off of such solid substances into the brook on occasions of heavy rainfall. The consequence was that the late Sir Edmund Lechmere, Bart., M.P., living at the Rhydd, on the banks of the Severn, at the junction of the Pool Brook with that river, found that the off-flow from the sewaged land polluted his water supply and brought down to his residence unmistakable signs of sewage. On his representation of these facts the local authority decided to alter their mode of sewage disposal.

The town of Great Malvern stands upon the somewhat precipitous slopes of the hills known as the Malvern Hills, and the locality, being subject, as stated, to occasional heavy falls of rain, a large quantity of water is thrown off the surface, the


No. 5.
G.
From North Malvern
LAND THAT CAN BE IRRIGATED
ION
From Malvern
Homest
to River Severn
EFFLUENT OUTLET
STORM WATER OUTLET
OZIER BEDS
BAILEY, DENTON, SON & NORTH,
PALACE CHAMBERS, WESTMINSTER.
Thos Kell & Son, Lith.

greater part of which had been admitted into the sewers, to find its way by them to the sewaged land at the time when Sir Edmund Lechmere's complaint was made. More than 2 inches of rain have not unfrequently fallen in 24 hours, and as much as 8,000,000 gallons have been thrown off the tributary area.

The local board having in 1878 sought advice from the writer's firm, it was determined to separate as far as practicable the surface waters from the sewage proper, and to exclude the former from the sewers. It was further decided that in lieu of surface irrigation alone, as previously practised, the process of intermittent filtration in combination with and as a safety valve to surface irrigation, should be adopted, and that more pains should be taken than hitherto to prepare the surface over which the sewage was distributed in order that it might be absorbed rather than thrown off. It was found, however, that the work of separation could not well be extended to the whole of the surface tributary to Pool Brook, the proportion, to which a means of interception could be favourably applied, being limited to about two-thirds of the whole tributary area, or about 230 acres, thus leaving more than one-third still discharging its surface waters into the sewers.

By this separation at least 5,500,000 gallons of surface water were removed from the sewers in times of storms, and the land now used for the cleansing of the sewage was relieved to that extent without depriving the outfall stream of the district of its natural supply for any length of its course.

In 1878 the resident population contributing sewage to the sewers of this portion of Malvern was estimated to be 4000, increased in certain months constituting the season to 6000; but as the popularity of the district which was then great as a place of health resort was increasing, it was necessary to make a large provision for the future disposal of the sewage.

The quantity of sewage proper at that time measured by the water supply amounted to 150,000 gallons a day, but in looking to the dilution due to subsoil water which raised it to 350,000 gallons, and to the future increase of population, it was considered desirable to provide for four times the water supply as the dry weather discharge, whilst it was assumed that in wet

weather the discharge might exceed 2,000,000 gallons in twenty-hours after the separation referred to.

To provide for such discharges the local board purchased about 40 acres of land, shown on drawing No. 5, about a mile lower down the Pool Brook valley than the land which had hitherto been utilised, at a cost of 7000*l.* Of this quantity 11½ acres were laid out for intermittent filtration, 24 acres for surface irrigation, and 2½ acres for the growth of osiers through which to pass the surplus water in times of rainfall, the remainder (2 acres) being taken up in roads, barrow paths, tanks, &c. The land is of a mixed character on the New Red Sandstone formation, consisting of marl and clay intermixed with gravel of a sufficiently hard texture to supply the material for the roads on the farm. The filtration areas are eleven in number, and together form a square block in the centre of the 40 acres where the soil is freest, each area approximating 1 acre in extent; and such was the absorbent character of the soil after careful underdrainage, that the whole of the dry weather sewage (350,000 gallons) was frequently disposed of for several days in succession on a single area only, and an effluent of a superior character obtained at the same time. With this fact established, and with the power of applying the sewage intermittently to any of the eleven areas, it soon became manifest that the quantity of land devoted to intermittent filtration would, except under extraordinary circumstances, be of itself sufficient to cleanse the sewage for many years to come without having recourse to any of the 24 acres of surface irrigation for intermittent filtration.

Beyond this combined arrangement there is the capability of applying the sewage to other land outside the 40 acres, which exists at a level to receive it by gravitation. The main delivering conduit, in fact, has been laid at a height to command additional land if the authority should determine either to increase the size of their sewage farm or to sell the sewage for use on neighbouring farms.

The cost of preparing the whole of the 40 acres for the reception of the sewage did not exceed 3300*l.* This included the underdrainage and the surface formation of the whole, as well as the construction of tanks, delivering conduits and dis-

tributing chambers, the formation of roads and osier beds, iron fencing, entrance gates, osier planting, the flushing arrangement of the underdrains, the charges of the engineers and wages of the clerk of works. The total cost of land and preparation did not exceed 10,100*l.*

The difficulty of carting over land, of which clay and marl are constituents, in winter and spring, when heavy loads of savoys and other cabbages have to be removed to market, rendered it necessary to form roads of a somewhat expensive character.

In 1880 a sample of the effluent from the underdrains was taken and submitted for analysis, after the sewage had been on one area for several days, as it was considered that such would be a very severe test of its character.

The following is the analysis of Professor Attfield:—

ANALYSIS OF EFFLUENT FROM GREAT MALVERN.

17 BLOOMSBURY SQUARE, LONDON, W.C.,
December 16th, 1880.

"The appended data show that the amount of impurities in this effluent are well within official limits, and hence that it is admissible into any ordinary river.

"The first of the following two columns of figures shows parts per 100,000, the second column parts per 70,000 parts (grains per gallon) of the respective substances contained in the effluent.

—	Parts per 100,000 Parts.	Parts per 70,000 Parts or Grains per Gallon.
Total solid matter dried at 212° F.	37·2	26·0
Nitrogen (as ammoniacal matter)	·33	·23
Nitrogen (as organic matter)	·024	·017
Nitrogen (as nitrates and much nitrites)	·24	·16
Chlorine (as chlorides)	3·3	2·3
Temporary hardness (as chalk grains or degrees)	11·0	8·0
Permanent hardness (as chalk grains or degrees)	13·0	9·0
Total hardness (as chalk grains or degrees)	24·0	17·0
Lead or copper	None	None.

The effluent is clear and almost bright.

(Signed) JOHN ATTFIELD.

It will be seen by reference to the accompanying drawing, that osier beds for the cleansing of such storm water as may be suddenly brought down on the farm in excess of the quantity the land will absorb, are situated at the lowest margin of the land next the outfall stream. They were formed out of ground of uneven surface. The object of these ozier beds is not that of filtration *through the soil*, but simply to arrest the solid matter floating about in the storm water on its way to the outfall stream, to effect which the osiers are planted on ridges, in areas formed on several levels descending by steps to the outlet. By this means the storm water passes from one level to another, and deposits such solid matter as it may contain in the furrows.

In 1891 several new districts, notably North Malvern, were added to Great Malvern, so that the population contributing to the sewage farm was unexpectedly much increased. The local authority therefore thought it right, under these altered circumstances, to again request the writer's firm to advise them as to what steps they should take to accommodate this great increase of sewage. As a result, in order to secure more active percolation of the soil, they were recommended to underdrain the filtration areas more closely, i. e. at intervals of half a chain between each drain as against one chain. The authority followed this advice, and at the same time constructed additional depositing tanks for the newly added districts, from which the sludge is raised by an ordinary sludge pump, and placed on sludge beds adjacent to the tanks, and then mixed with the town ashes. By this means it was considered that it would not be necessary, as foreshadowed in the engineers' report, to increase the size of the farm, but to leave such extension as the next step, which may not perhaps be very long delayed, owing to the growing popularity of Malvern as a health resort, and to there being other adjacent districts which must sooner or later be incorporated with it.

When the work of alteration was completed in 1892, and the farm was again handed over to the local authority, the following rules of management were framed for the use and guidance of the waterman. They are here given as illustrating a mode of management which should be adopted on all sewage

farms, especially in those cases where rapid increase of population renders the careful and systematic treatment of the sewage a matter of absolute necessity.

MALVERN SEWAGE FARM.

Farm Manager's Instructions.

1891–1892.

"Only such crops to be grown as are suitable for sewage application, and no filtration areas to be sown with cereals.

"The farm manager is responsible that the four tanks are regularly cleaned out whenever they are full of sludge. He cannot be directed at what intervals of time this should be done, for the quantity of sludge in the sewage constantly varies, but directly a tank is full, i. e. as soon as the surface of the sludge collected in the pit which is provided for the purpose is level with the bottom of the screens, the tank must be emptied by means of the sludge pumps, and the sludge mixed with ashes placed in a heap at the two selected sites.

"The furrows in the osiers must be cleaned out at least twice a year, in the spring and autumn.

"The furrows in each of the filtration areas must be cleaned out once a month. This cleansing of the furrows when done regularly will not entail great trouble or labour.

"The system of sewage disposal is to be as follows:—

Sunday	Upper rye-grass and land below farm buildings.
Monday	Areas V., X., XI.
Tuesday	„ V., X., XI.
Wednesday	„ III., IV., VIII., IX.
Thursday	„ III., IV., VIII., IX.
Friday	„ I., II., VI., VII.
Saturday	„ I., II., VI., VII.

"Night sewage is to be alternately distributed over the rye-grass field and further meadow, and occasionally over the land below farm buildings. It will probably be found that the upper rye-grass, and land below farm buildings will be able to absorb

profitably more sewage than the Sunday delivery, in which case these portions may be brought into use during the afternoon to assist the areas.

"The osier beds are reserved for use during times of heavy rainfall, and the valves both in the Great Malvern and the North Malvern outfall sewer must be so fixed that the storm overflows at the two manholes should of themselves come into action at such times. It may be necessary occasionally either to raise or lower these valves, but under any circumstances this should be done with great care and discretion.

"The manager is required to furnish a weekly report to Messrs. Bailey-Denton, Son & North, as to the result of following out these rules. He is to state shortly in these reports where the sewage has been placed daily and nightly, the times, if any, upon which the storm overflows, have come into action, and the length of time they have remained so, and especially the condition—i.e. dryness—of each area before the sewage is turned into it.

BAILEY-DENTON, SON & NORTH.

PALACE CHAMBERS, WESTMINSTER."

As evidence that the alterations carried out three years ago, have secured the desired effect, the writer appends the following letter, dated the 8th of July, 1895, from the Local Engineer.

"COUNCIL OFFICES, MALVERN.

"DEAR SIR,—I have thought you would be pleased to know that the reports of effluent from farm are always good.

"When I spoke to Gatfield (the waterman), at the end of the severe weather last winter, he said he had no trouble with the beds. They had continued to do the work well.

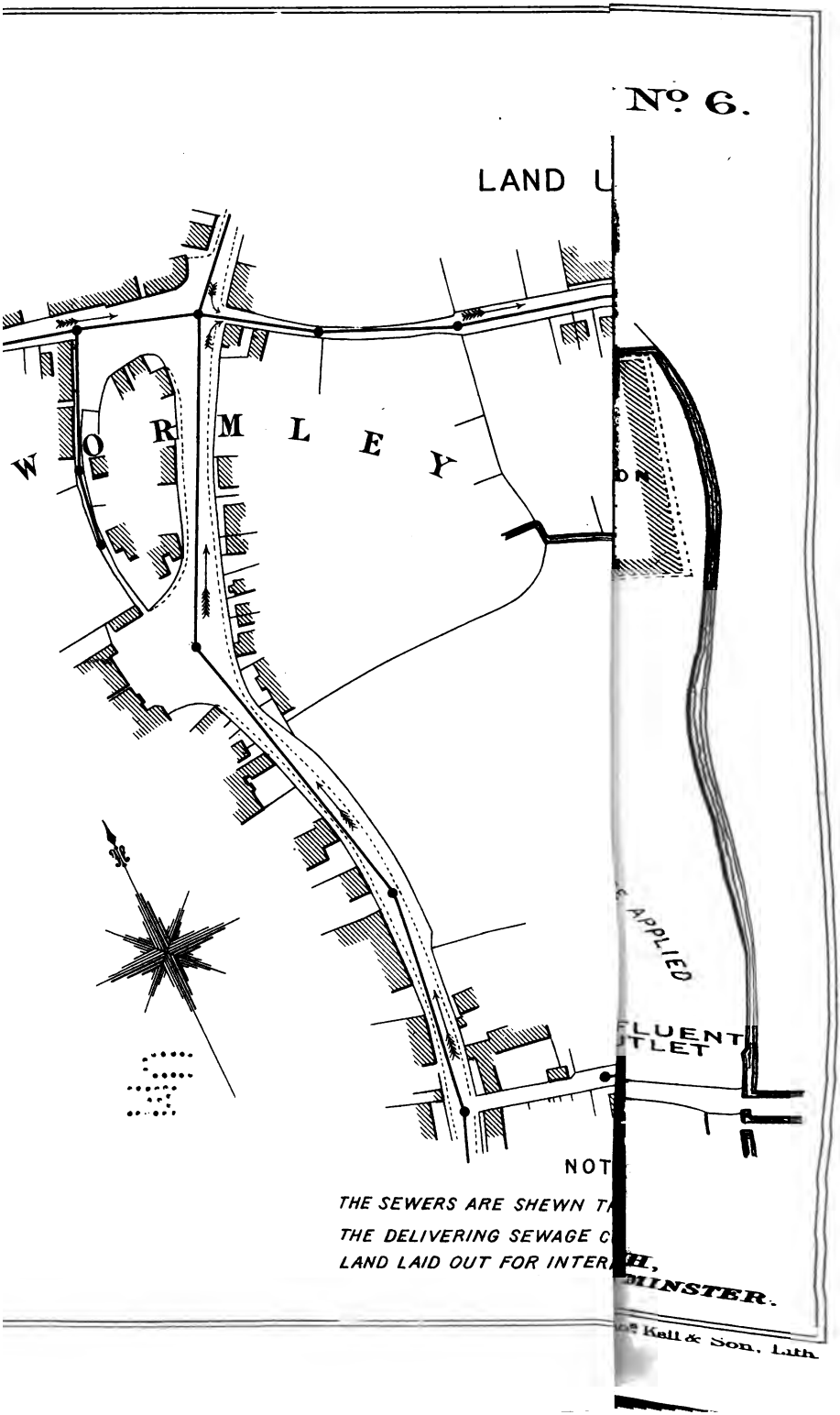
"I enclose a copy of last year's balance sheet, which may also be of interest to you.

I am, yours very truly,

A. O. FRASER.

E. BAILEY-DENTON, Esq."

The balance sheet referred to in the above letter is given below.


No 6.
LAND U
W O R M L E Y
APPLIED
FLUENT
UTLET
NOT
THE SEWERS ARE SHEWN TH
THE DELIVERING SEWAGE O
LAND LAID OUT FOR INTER
H,
MINSTER.
Kell & Son. Lith

ABSTRACT OF THE ACCOUNTS OF THE MALVERN LOCAL GOVERNMENT BOARD FOR THE YEAR ENDING 25TH MARCH, 1894.

Sewage Farm.

Dr.	£	s.	d.	Cr.	£	s.	d.
To attending fairs	3	4	0	By sale of cattle, pigs, manure, and general produce	642	12	9
„ cattle and pigs	258	3	0	„ transfer horse account, chaff cutting, grass, &c., for horses	69	14	0
„ cake, bean meal, sharps, &c.	14	3	0	„ district fund	7	6	10
„ bailiff's wages	70	4	0				
„ seeds	15	7	2				
„ horse hire for ploughing, &c.	14	5	0				
„ mens' wages attending cattle, cultivating crops, distributing sewage, &c.	289	2	1				
„ repairs to buildings, implements, &c., coal, tithe, rates, insurance, bricks, pipes, harness, and sundries in connection with the farm	55	5	4				
	£719	13	7		£719	13	7

WORMLEY, HERTS.

THIS instance is given as an illustration of a successful mode of treating the sewage of an ordinary agricultural village. The population tributary to the sewers may be taken to be about 900. The village is provided with a public system of water supply, recently completed by the writer's firm, but only a portion of the inhabitants at present make use of it, the remainder continuing to draw from old shallow wells sunk into the gravel, which are always liable to pollution. There are no special trades in the district. The land to which the sewage flows by gravitation is situated in the Lea valley at a distance of about half-a-mile from the village, between the Great Eastern Railway and the river. It consists of about two acres, with capability of extension to between five and six acres, should a sufficient increase in the population of the village ever necessi-

tate the extension. On the land, all of which is laid out for intermittent filtration, everything connected with the disposal of the sewage is of the simplest description. At the small open tanks built at the mouth of the outfall sewer, the larger matters merely are screened by means of ordinary gratings, whilst the road detritus and heavy ingredients contained in suspension fall to the bottom, which was specially shaped for this purpose. By this means the liquid, robbed of none of its manurial or valuable properties, is applied to the four plots or areas constituting the garden, upon which roots and rye-grass are grown. The sludge deposited in the tanks, having been raised to the surface as occasion demands, by a simple chain pump, is mixed with ashes brought from the village upon small sludge beds made in close proximity to the tanks. From these beds most of the liquid in the sludge is soon conveyed back into the tanks by means of shallow underdrains, whilst the solids are periodically taken away and dug into the soil. The preparation of the land cost about 200*l.*, and it is now leased to an inhabitant of the village at a rental of 1*l.* per acre.

The drawbacks attendant on the local authority surrendering the control of the sewaged land, have been, it is hoped, minimised by a very stringent agreement which enacts that the efficient disposal of the sewage and the securing of a good effluent must be the primary consideration with the tenant, who is likewise bound to keep the land in thoroughly good order, and to apply the sewage to each filtration area carefully in turn.

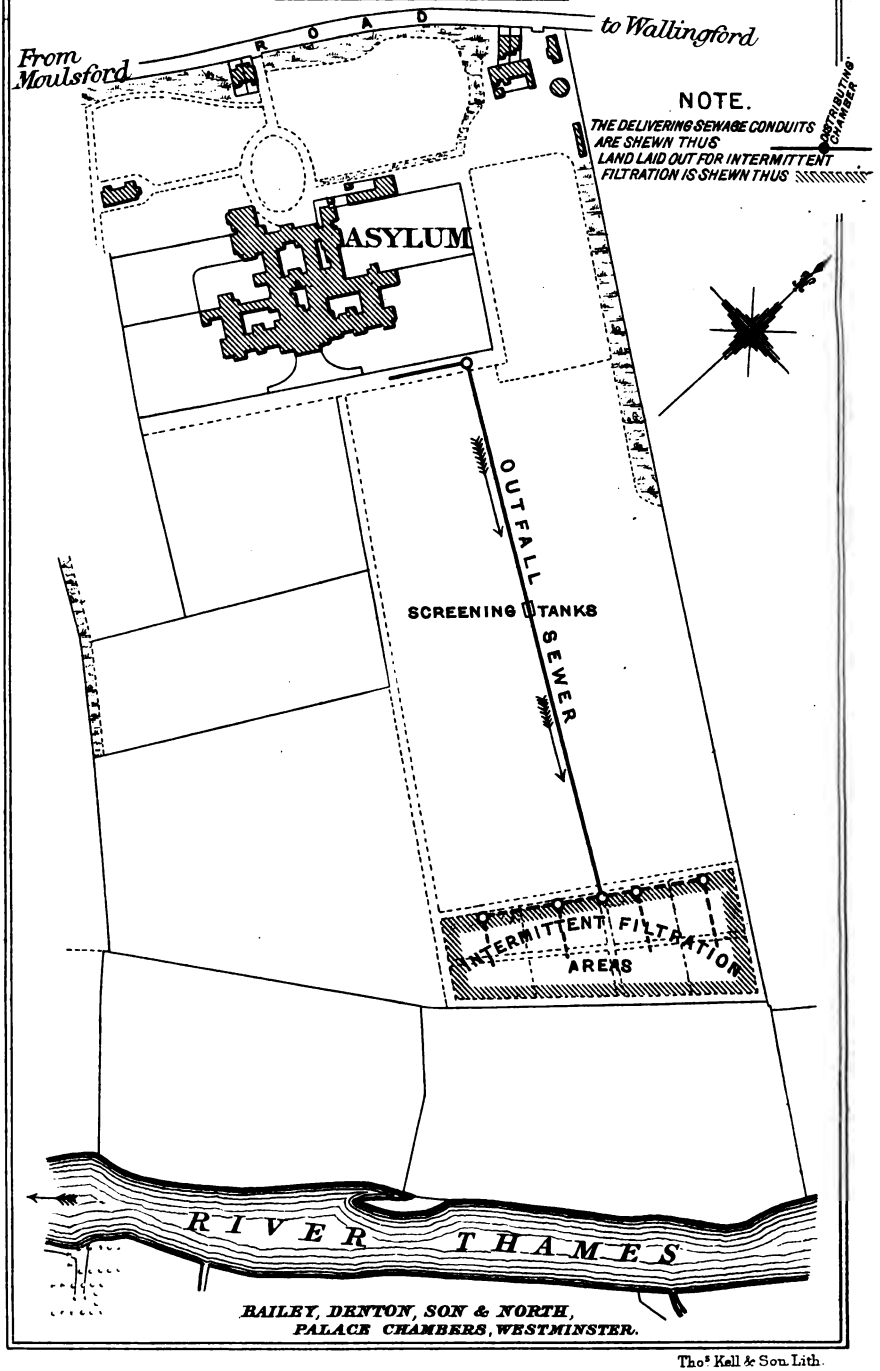
The land is underdrained to an average depth of 5 feet 6 inches below the surface, and the effluent, after its discharge into an adjacent watercourse, ultimately finds its way to the Lea at a distance of about eight miles above the intake of the East London Water Company at Chingford.

That Wormley is a successful instance of intermittent filtration is proved by the fact that after a trial of two years the effluent is still very satisfactory, as proved by the accompanying analysis by Dr. Bernard Dyer, who thus describes it.

BERKS COUNTY LUNATIC ASYLUM.

PLAN SHEWING SYSTEM OF SEWAGE DISPOSAL.

No. 7.



BAILEY, DENTON, SON & NORTH,
PALACE CHAMBERS, WESTMINSTER.

Thos Kell & Son Lith.

ANALYTICAL LABORATORY,

17 GREAT TOWER STREET, LONDON, E.C.
21*st November*, 1895.

Result of Analysis of a Sample of Effluent Water from the Wormley Sewage Garden, taken on November 4th, 1895.

	Grains per Gallon.
Total dissolved matter	35·00
Loss on incineration of residue	4·00
Chlorine in chlorides	3·30
Equal to chloride of sodium	5·44
Nitrogen in nitrates	·54
Equal to nitric acid	2·10
Free (actual or saline) ammonia	·168
Albuminoid (organic) ammonia	·014
Oxygen absorbed by oxidisable organic matter, &c., from a solution of permanganate of potash at a temperature of 80° F. :—	
In 15 minutes	·127
In 4 hours	·179
Phosphoric acid	Traces only.
Appearance in two feet tube	Clear.
Suspended matters	Mere traces.

I am of opinion that this is a good effluent, quite fit to turn into a watercourse.

BERNARD DYER, D.Sc., F.I.C.

BERKS COUNTY LUNATIC ASYLUM.

UNTIL the summer of 1889, the liquid refuse from this asylum, which is situated at Moulsford, was as a rule treated in a most primitive manner upon a vegetable and fruit garden belonging to the Institution, and in close proximity to the building, though at certain seasons of the year, especially during spring and summer, when the gardener thought it injudicious to apply the sewage to the growing crops, it was allowed to run, without any

treatment whatever, into an adjoining brook, and thence, ultimately, into the river Thames, which flows past the Asylum at a distance of about half a mile from it.

The inevitable pollution resulting from this state of affairs caused, in the year named, an inquiry into the whole question, with the result that the Committee of Visitors sought the advice of the writer's firm. As a result their recommendations were adopted, and they were instructed by the Committee to lay out and prepare for the purification of the sewage, 3½ acres of land in the situation shown on drawing No. 7, and at a distance of 430 yards from the nearest inhabited portion of the building.

It was determined to rely on intermittent filtration only, and to apply the sewage to as limited an area as possible. Soon after the work was commenced, the soil was found to be so porous that it was decided not to prepare more than half of the 3½ acres, the surface of the remaining half being merely roughly levelled at a nominal outlay so as to serve as a relief to the filtration areas should at any time occasion arise.

The soil is very favourable for the purification of sewage, inasmuch as at 18 inches below the surface, sand and gravel exist for a considerable depth without any clay whatever. The experience gained here during the last five years has proved that 1¾ acres of such soil, carefully prepared, would, without doubt, successfully and without the slightest nuisance, purify the liquid refuse discharged from about 2000 people, instead of the population of 600 to 800 people who now inhabit the asylum. It will be seen, therefore, that ample provision has been made should lunacy in Berkshire increase.

Owing to the natural porosity of the soil no underdrainage was necessary, and the sewage which is purified by downward filtration is never seen again after absorption in the furrows, the river Thames and its tributary ditches being thus entirely freed from contamination.

By reference to the plan it will be seen how the sewage flows by gravitation to all the four upper filtration beds or plots, which each contain less than half an acre, every plot being level in itself, but differing in surface height one from the other. A small open tank in duplicate, built at the point

indicated, for the screening and deposition of the coarser matters held in suspension, which as they collect are removed from it and mixed with the soil of the adjacent field, has been found to answer all the requirements of the institution.

As to the continued success of the sewage garden, the chief medical officer, Dr. Murdoch, thus writes under date July 1st, 1895:—

"With regard to our sewage garden which was laid out some few years ago, we beg to state that last year we had excellent crops of savoys and other vegetables. This year the crop is principally mangold. The land appears to take the sewage as freely as ever."

By a visit to Moulsford in September of last year, the writer was able to assure himself that the complete success of the sewage garden is fully maintained, the only drawback being that there is not, perhaps, sewage enough to satisfy the soil. The crops of roots and vegetables, however, looked most flourishing, and the head gardener stated that he was always able to produce the best sample of roots in the neighbourhood.

The actual cost of preparing the land for the reception of sewage cannot be given, nasmuch as most of the labour was done by the inmates of the asylum, acting under the instructions of a clerk of works representing the engineer, but the cost of the materials used, and the professional charges, amounted to only 130*l.*

The ratepayers of Berkshire have, therefore, no cause to regret the adoption of intermittent filtration at their county asylum, for it has been as successful in result as the cost of the works was moderate.

FONTHILL, EAST GRINSTEAD.

School Establishment containing about Eighty persons.

THIS case is an excellent example of how the sewage of large country mansions and schools, which is now so generally either wasted or allowed to create a nuisance, may be profitably utilised at a moderate cost.

In this instance, until the spring of 1895, a large cesspool, which was never emptied, received the sewage from the house and out-offices, and its overflow, which was often most foul, was allowed to run into and thus pollute a neighbouring ditch containing running water.

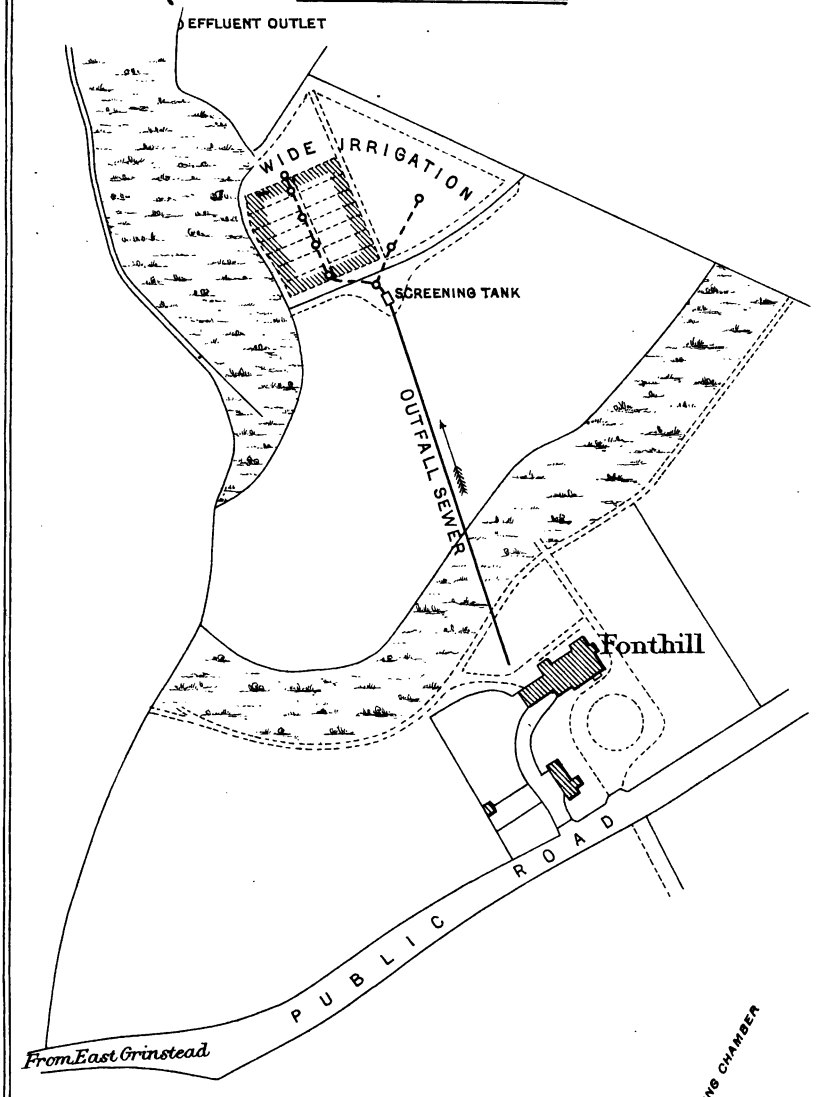
In consequence of very justifiable complaints resulting from this pollution, the writer was consulted as to a remedy, and he naturally recommended the abolition of the covered cesspool system, and in its place the purification of the sewage through land, there being soil of a suitable character favourably situated on the slope of a hill within the boundaries of the property and at a suitable distance from the house. As a result, three-quarters of an acre of land were laid out and prepared, this comparatively large area being utilised on account of the probability of another house and school being built on the same property, the sewage from which would flow to the one site of disposal. Of the three-quarters of an acre, one-quarter has been laid out in horizontal beds, each being about 25 links wide, for intermittent filtration; and the remainder contoured for wide irrigation in the usual manner.

Vegetables are grown upon the filtration beds, the sewage in the furrows never being allowed to rise sufficiently high to flow over them or in any way to touch the leaves of the growing plants, lateral percolation through the soil towards the roots being amply sufficient to secure good crops. On the irrigation ground roots are grown for the consumption of stock.

No. 8.

FONTHILL, EAST GRINSTEAD.

PLAN SHEWING SYSTEM OF SEWAGE DISPOSAL.



NOTE.

THE DELIVERING SEWAGE CONDUITS ARE SHEWN THUS _ _ _ _ _ _

THE LAND LAID OUT FOR INTERMITTENT FILTRATION.

BAILEY, DENTON, SON & NORTH,
PALACE CHAMBERS, WESTMINSTER.

Thos Kell & Son, Lith.

In place of the large covered cesspool a small open tank has been built, designed to contain only a limited quantity of sewage, so that any lengthened collection of stale liquid to give off bad smells is impossible, a specially necessary precaution in the case of a school. A penstock in this tank is raised once or twice a day by a servant whose duty it is to attend to the sewage garden, and in this manner the liquid is delivered by means of 4-inch pipes to whatever part of the land it is desired to apply it. Should the requisite daily emptying of the tank be for any reason neglected, an alternative pipe at a higher level, which is connected with the distributing conduits, comes into operation, and thus any overflow is prevented.

By this means the percolation of the sewage through the land cannot under any circumstances be avoided. The soil, which is of a free description intermixed with clay, has been underdrained, where necessary, to a minimum depth of 5 feet 6 inches by means of 6-inch pipes, and the effluent is conveyed to the same watercourse as formerly, in a perfectly purified condition.

By reference to the plan it will be readily understood how the sewage is delivered to any portion of the land at the will of the gardener.

The cost of the whole work, including labour, materials and professional charges, amounted to no more than 166*l.* 8*s.*, whilst the produce of the sewaged land goes a long way to meet the wages of the gardener employed in attending to the daily distribution of the sewage.

Mr. Radcliffe, the owner of Fonthill, thus writes under date of January 10th, 1896:—

"The scheme seems perfectly satisfactory. The tank has to be emptied morning and evening. The gardener expresses himself quite satisfied both with the system and the work. I shall always be glad to show the garden to any one you send for instruction."

STANDING RULES

TO BE OBSERVED WHEN ADOPTING LAND TREATMENT.

HAVING selected eight cases of Land Filtration, varying in size and character, as illustrations of what may be done in different localities, it may be well to state, in the order of their importance, the governing rules essential to the successful (i. e. profitable) disposal of sewage when recourse is had to land as the cleansing medium.

1. Foreign waters— ubsoil water, surface water, and liquid trade refuse—should be as far as practicable excluded from the sewers of all districts, inasmuch as it matters not what the precise treatment of the sewage be—irrigation or filtration in combination or otherwise—it is certain that if the sewage proper be diluted to such an extent that the *modus operandi* is at times deranged, failure or injury results.

2. The preparation and formation of land to receive sewage should be effected *with precision*, and not in the careless way in which it has been suggested sewage farms may be laid out. Irregular surfaces and steep slopes should be avoided even more carefully than clay soils, for all liquids will run down sloping surfaces and collect in the lowest places, to the injury of crops and the creation of nuisance; and the more sewage is diluted with foreign waters, the greater will be these evils. There is no economy in carelessly executed land-preparations, and it is greatly to be regretted that such views have been inculcated.

3. Intermittency of application and regulation of quantity should take the place of the haphazard distribution which prevails on most sewage farms, for it is the want of these *desiderata* which brings discredit to the engineer and loss to the farmer. With sewage *intermittently* distributed, in quantities apportioned to the extent of surface to which it is applied, the best results are obtained. Intermittency of application is positively essen-

tial to a continued good effluent. Where an inferior effluent from underdrains is found, it is invariably due to *constant* filtration through the same land.

4. Where Intermittent Filtration areas form part of an irrigation farm, a sufficient proportion of the areas should be always ready to receive the sewage, when it cannot be beneficially applied to the remainder, or to receive so much of it as may be in excess of what the remainder will absorb with advantage.

5. The underdrainage of both Filtration areas and Surface Irrigated land should be laid out as carefully as practical science will suggest, so as to avoid drawing the liquid sewage down from the surface to the drain without passing through the undisturbed ground on each side of it.

6. Means should be taken in connection with screening to intercept road detritus as far as possible, as it will be apt to fill up the furrows quickly.

7. With Surface Irrigation no single dressing of liquid, to be productive of benefit, should exceed an inch in depth; and directly the quantity applied to an acre of land exceeds that depth, which is equal to 100 tons, the surplus is positive waste, which should not be paid for. All land laid out for *irrigation* has sloping surfaces, which cause the liquid to run down to the lower portions of the surface, and to rest there in slacks and hollows until it is absorbed or evaporated, doing mischief in the meantime. The farmer paying rent for land with sewage soon finds this out. He knows that he cannot profitably apply more than 20,000 gallons at a dressing except to fallows, *bare of vegetation, which no sewage farmer ought to* have in the growing seasons.

Experience, in fact, goes to prove that sewage, let its intrinsic value be what it may, directly it is delivered to land by way of Surface Irrigation, without that systematic arrangement which will secure regularity of distribution in the quantities that will be beneficial, ceases to be of any value at all. Without system the distribution of sewage on the surface becomes what has been termed "intensive irrigation"—or in other words the "getting rid of the sewage in the quickest way"—with an

indefinite chance of turning its fertilising ingredients to some account at the same time, when harm rather than good is frequently done.

The Qualifications of a Sewage Farmer, Etc.

As to the qualifications of a sewage farmer, experience has made it manifest that to secure any chance of profit in sewage farming, the liquid must be distributed in regular quantities and at proper times, and all practical men are also satisfied that the early expectations entertained as to the general applicability of sewage to ordinary farm crops cannot be realised, and that a sewage farmer to qualify himself for success must serve a special apprenticeship to the occupation. Moreover, it has been made clear that an ordinary farmer is no better qualified to deal with sewage without such apprenticeship than a gardener; for not only is it necessary to know what grasses and vegetables can be best treated by sewage, and to regulate the frequency of application and the quantity of liquid to gain the best return, but it is absolutely essential that he should be able to effect the best and readiest sale of his crops when fit for market, and so to conduct his operations with reference to the demands of local markets and of such other markets, as he can best reach, as will conduce to the growth of only such crops as he can most readily sell. By this means he will reduce to a minimum the losses incidental to all food production, for it is quite certain that in the long run the man *who sells the most at the right moment, and who aims at converting into milk or meat what he cannot sell*, is the person who will make the most money. To do this it is absolutely requisite that every sewage farm should have upon it sufficient buildings to house a proper number of milch cows and pigs, to consume a portion of each season's produce.

It is essential, in fact, that a tenant of a sewage farm should combine in his own capabilities the practical qualities of a farmer, a gardener, and a market salesman, which will induce him to avoid all treatment of a *dilettante* character, and lead him to embrace in his management the growth of such crops only as will keep him most favourably before the markets he

serves. Many of the ordinary farm crops are injured by the application of sewage to them. Cereal and pulse crops, instead of being benefited by its *direct* application to them while in growth, are damaged by the increase of straw at the expense of the grain; potatoes and turnips are also injuriously affected in a like manner. Kohl Rabi seems to do better.

It is equally true that heavy crops of both grass and vegetables may be produced without the capability of selling them. Not many years back the possibility of growing Italian rye grass without the certainty of sale or conversion was ridiculed as an absurdity, yet the last few years have satisfied all sewage farmers that it is not only possible to grow more rye grass than can be sold, but that if retained for conversion, either into milk or into hay, it is very problematical whether, in one way or another, some loss does not attend the operation. Still there are crops which, when advantageously selected, cannot fail to yield a profit if the liquid is rightly applied.

Up to a limited extent, rye grass, of all productions, is that which best responds to the use of sewage—unless it be prickly comfrey, which is an excellent forage plant for horses, and may be profitably consumed with rye grass by cows. Moreover, it has been found that it can never be overdosed with sewage.

All the cabbage tribe are also greedy of sewage, and although, in certain seasons, it is very easy to have too many for market, there is no doubt that in the long run they pay well, particularly if pigs are kept on the farm to consume any unsold surplus. The Enfield Market, Colewort, and Ox-heart cabbages, if they stand through the frost of winter, realise a good return in early summer, while savoys and drumheads—which latter, though more frequently treated as the food of cattle, sell remarkably well to the inhabitants of the manufacturing and mining districts—are generally very saleable in late autumn and winter. Under good management the two crops of cabbages of summer and winter are grown in the same year on the same land—that is, the summer cabbages planted in October are cut in May or June, when the land is again prepared for savoy and drumhead cabbages, which

may be planted in sufficient time to be cut the following winter, and the ground cleared in time for a succession of roots.

But, on the whole, mangolds (long red, tankard and globe) form the best crop for the sewage farmer, if the selected seed is good, and it is carefully sown, and advantage is taken of a command of sewage for timely watering to secure a plant. The weight of crop will always vary with the temperature of the summer, but under any circumstances the crop from a sewage farm will, compared with that from an ordinary farm, surpass it in both weight and quality. It would appear that if the land is *well drained*, so that the liquid readily percolates, mangolds, of all roots, will flourish best with a superabundance of liquid. Some years ago the writer grew on 13 acres of land, forming part of the filtration areas at Hitchin, 400 tons of these roots, which is equal to 31 tons to an acre. These 13 acres received, perhaps twice a week, 100,000 gallons per acre. The mangolds were raised, carried from the peaty soil, and clamped ready for sale, at a cost of 45*l.*, realising, at 1*l.* a ton clear of carriage, 27*l.* 6*s.* per acre.

Carrots and parsnips do equally well in a free sandy soil. At Forfar a price equal to 56*l.* an acre has been gained by the growth of carrots on the filtration areas. On inferior free soils, the Intermediate Red carrots are best, but on naturally deep sandy loams the Altringham Reds yield the greater weight. White carrots for cattle pay well in suitable soils, but with them and all other sorts of carrots, as well as with parsnips, no amount of sewage will make an unsuitable soil productive of heavy crops.

Sewage farmers, as a rule, should avoid the growth of crops which have not been well tried. Much money is lost by experiments in *refined* vegetable gardening, such as the growth of lettuces, parsley, vegetable marrow, sugar beet, &c.

Probably onions, if the soil is compact and suits them, and good judgment is used in watering them, pay better than any other crop, but there are few places where this root will succeed. They are altogether unfit for the superabundant watering of filtration ground.

To a small extent, rhubarb, celery and strawberries may be advantageously grown.

Some capital roses also have been produced on the Hitchin Sewage Farm.

CONCLUSIONS.

THIS Treatise would fail in one of its purposes if it were brought to a close without an expression of the conclusions to which the writer has been brought, by the experiences of recent years, in relation to the different modes of sewage disposal now practised in this country, and the effect they have had in promoting the production of food for our rapidly increasing population.

The conclusions are:—

(1) Excluding from consideration sea-board towns, the sewage of which it may be expedient to discharge into the sea, the instances are few in which the liquid refuse discharged from human habitations may not be more economically cleansed by recourse to land than by any chemical precipitation.

(2) That the exceptions are only those where land cannot be obtained.

(3) That the more minute or finer floating solid matters, which cannot be separated from the liquid by screens or rough filter beds, designed to arrest the larger solids, form no bar to the use of land as a purifier. Such ingredients, when conveyed to land, where they are always wanted, instead of clogging it help to make it more percolative and more productive than it would be if such materials were withheld.

(4) That if, instead of leaving sewage when applied to land to flow where it will over irregular surfaces, in the varying quantities in which it is usually discharged from towns, proper steps were taken to deliver for surface irrigation only such quantities as are wanted by the cultivator—by taking advantage of the power we always possess of cleansing any quantity of